OBSERVATIONS FROM THE CERTIFICATION AND OVERSIGHT OF THE WASTE ISOLATION PILOT PLANT

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ABSTRACT

The US Environmental Protection Agency (EPA) developed environmental standards for the US Department of Energy's (DOE) Waste Isolation Pilot Plant (WIPP) used by DOE for disposal of defense related transuranic wastes. EPA implements those standards for the deep geologic disposal system at WIPP, which has been operational for over 10 years. The general environmental standards applicable to WIPP are set forth in the EPA's 40 U.S. Code of Federal Regulations (CFR) Part 191 Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes. The standards are established for a 10,000 year compliance period. Compliance with these standards is determined, in part, by performance assessments that develop numerical results that can be compared to a numerical limit. These standards are implemented by site-specific compliance criteria standards (40 CFR Part 194), with EPA oversight of DOE. With ten years of experience, there is a trend of increasing calculated radionuclide releases calculated in multiple performance assessments primarily as a result of changes to parameter values.

1.0 BACKGROUND

The U.S. Environmental Protection Agency (EPA or the Agency) developed environmental standards for the disposal of defense-related transuranic wastes for the U.S. Department of Energy's (DOE or the Department) Waste Isolation Pilot Plant (WIPP). EPA implements these standards for WIPP, which has been in operation for over ten years. The general environmental standards are set forth in the Agency's 40 CFR Part 191 Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes [1]. These standards are implemented by site-specific compliance criteria [2].

The U.S. Environmental Protection Agency regulates the U.S. Department of Energy's Waste Isolation Pilot Plant, located in southeastern New Mexico. The repository is ~650 meters below ground surface in a thick bedded salt formation that dips from West to East at ~ 1^{o}. WIPP is located in the Chihuahuan Desert of New Mexico, where the annual precipitation averages between 25 and 40 centimeters and there is high evapotranspiration (See Figure 1). The current climate at WIPP appears to have been arid for at least 500,000 years as indicated by the widespread presence of surficial soil known as the Mesacalero Caliche. Most of the groundwater in the vicinity of WIPP is highly saline, with no significant drinking water available.

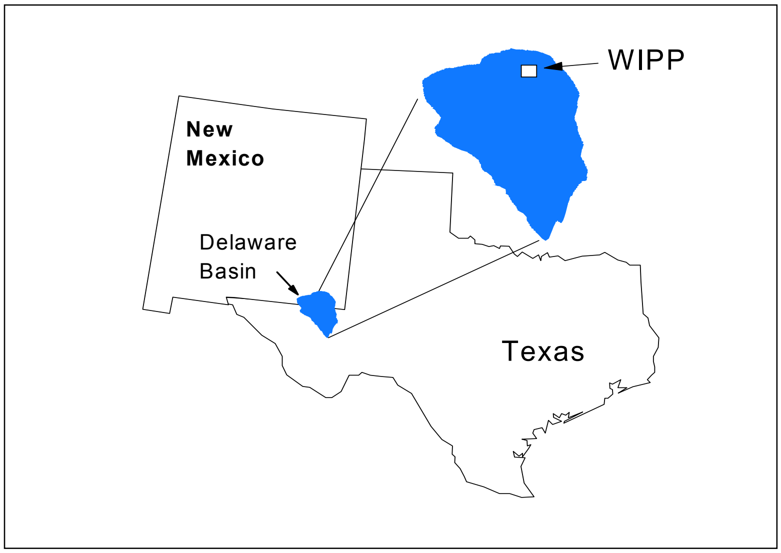

Figure 1. WIPP Location in the Southwest US

The transuranic waste disposed of at WIPP consists of materials such as radioactive sludges, soils, and laboratory materials (e.g., chemical mixtures, contaminated glove boxes, paper, and glass). Wastes are typically not treated unless necessary for shipping purposes (e.g., to limit hydrogen build-up). The waste is contaminated with plutonium, americium, and other radionuclides, including some cesium and strontium. Transuranic waste is defined as waste with radionuclides heavier than uranium containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste; isotopes must have half-lives greater than 20 years.

EPA certified (licensed) WIPP for operation in 1998 [3]. WIPP is required to be recertified every five years after initial receipt of waste, which took place in March 1999. Recertification applications prepared by DOE must consider any information that has changed or been learned since the prior certification (e.g. new experimental results or anticipated waste streams), as well as any changes to the disposal system (e.g., design changes). Updated performance assessments (PAs) have been submitted with each compliance re-certification application (CRA). Since WIPP has been in operation over ten years, two such compliance Recertification performance assessments have been conducted (the 2004 CRA PA and the 2009 CRA PA). Additionally, during each certification, EPA has required DOE to develop a second performance assessment reflecting code corrections or changes in computer code parameters. Six performance assessment calculations have been completed to date, and total releases predicted by each calculation can be compared.

2.0 WIPP PERFORMANCE ASSESSMENT

2.1 Release mechanisms at WIPP

Releases from WIPP are expected only if there is human intrusion into the repository. Under undisturbed conditions no migration of radionuclides to the disposal system boundary is expected to occur. The salt and several associated anhydrite interbeds have extremely low permeability and there is little movement of contaminants out of the waste area in the undisturbed case. The shaft seals, consisting of salt in the salt section, are assumed to have long-term low permeability and the modeling shows little movement of radionuclides up the shafts. For a drilling intrusion, three types of direct releases are modeled in performance assessment (PA): cuttings and cavings, spallings and direct brine releases. Direct releases are defined as solid and liquid materials removed from the repository and carried to the ground surface through intrusion boreholes at the time of drilling. Cuttings and cavings are the solid materials removed from the repository and carried to the ground surface by drilling fluid during the process of drilling a borehole that intersects the repository. Cuttings are the materials removed directly by the drill bit, and cavings are the materials eroded from the borehole walls by shear stresses from the circulating drill fluid. Both are modeled to occur during every intrusion.

Spallings material is waste that fails and is forced into the borehole if repository pressure is high enough (~ 10 MPa) and the shear strength is low enough for the waste to fail. Direct brine releases (DBR) are releases of dissolved radionuclides in repository brine (from hitting a brine pocket below the repository or far field fluids that have migrated into the waste area) that reach the land surface; this scenario requires also high repository pressure. Though minor relative to the direct intrusion scenario, long-term groundwater releases could occur if repository brine travels up an intrusion borehole and reaches the Culebra Dolomite, the most transmissive hydrologic unit above WIPP.

Figure 2 is a conceptual model of an E1 intrusion scenario, in which there is a drilling intrusion into a brine pocket below the waste area. The shaft seals are assumed to be essentially impermeable and brine migration is limited laterally by low permeability within the waste area, thus any releases would be expected to travel up the borehole.

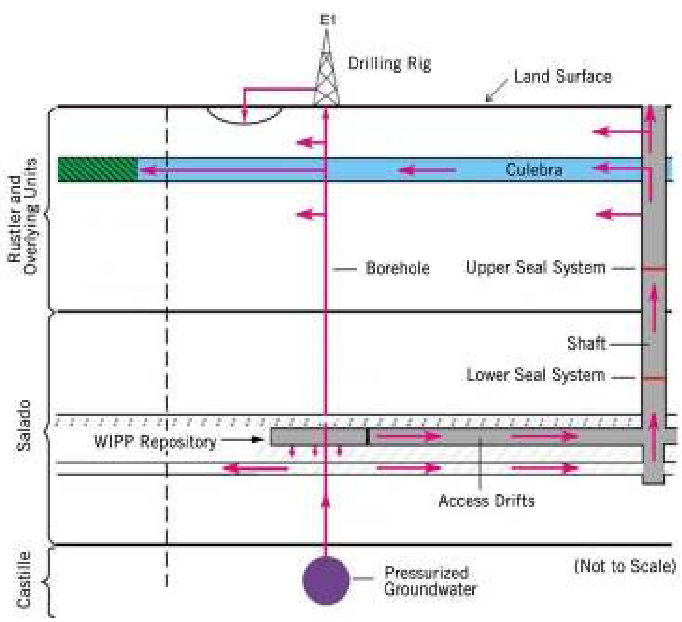

Figure 2 is a conceptual model of an E1 intrusion scenario which involves a drilling intrusion into the repository waste area and a brine pocket under the waste.

2.3 Trends in Modeled Releases

There have been three sets of performance assessments associated with DOE's modeling of the repository performance – one initial and one final PA for each certification. With each set of PAs, predicted releases at the 0.001 release probability (low probability, high release) have been observed to increase, while releases at the 0.1 release probability (high probability, low release) have remained relatively stable. The high probability release has not changed significantly due to the limited mechanisms (e.g., direct removal of drill cuttings) for a release to take place. The low probability, high consequence releases have been affected more than the high probability releases because they involve interdependent (e.g., pressure driven) drilling release mechanisms. Changes in important parameters have driven these increases. Figure 3 illustrates the trend in calculated releases.

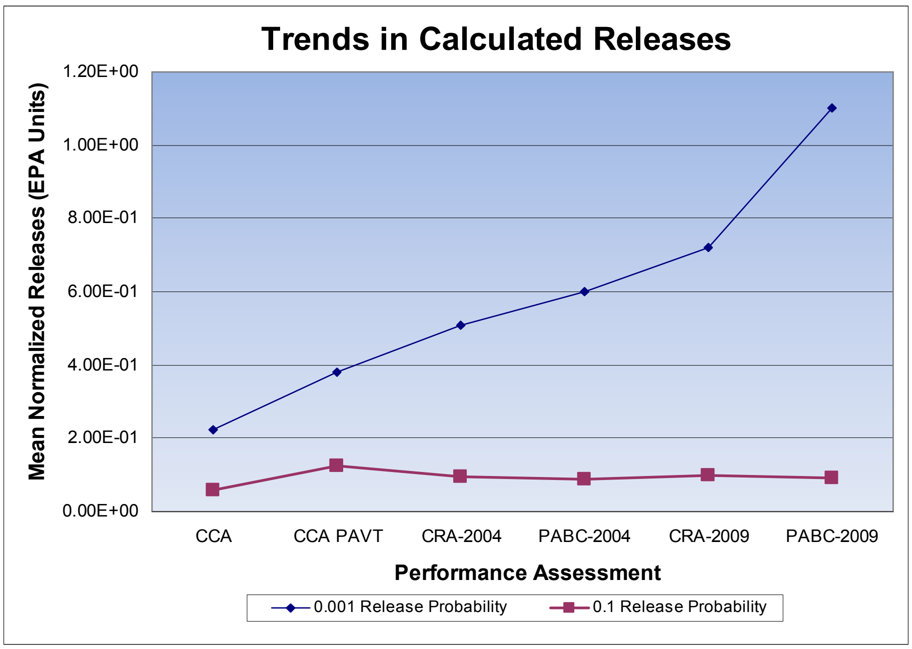

Figure 3. Trends in Releases Calculated for Multiple WIPP Performance Assessments
(The number of EPA units of a radionuclide is the activity (in Ci) of the radionuclide divided by the release limit for that radionuclide as established in 40 CFR 191. The compliance point the lower curve (0.1 release probability) is 1 and for the higher curve (0.001 release probability) the compliance point is10.)

2.4 Certification Application Performance Assessment

Changing the shear strength of the waste was the major reason for the increase between the original compliance certification application (CCA) PA [4] and the subsequent PA verification test (PAVT) [5]. Shear strength is a sensitive parameter because it affects the amount of cavings produced. This parameter's range was increased for the PAVT because the Agency identified that DOE did not adequately support the parameter on the lower end of the range, and an expert panel on a related topic (particle diameter size) increased the high end of the shear strength value. DOE eventually identified information that supported a very weak material and EPA accepted that information, understanding that it was probably unrealistically pessimistic. Thus, DOE chose a parameter value that could be easily defended, though it led to greater releases than would be reasonably expected. This is not the only case for which DOE adopted this approach in order to satisfy regulatory requirements. As the regulator, EPA did not object because the use of models or parameters that could be shown to be more conservative (that is, produce higher releases compared to alternative approaches) than other potential choices could be readily justified.

2.5 First Compliance Recertification Application

In the first compliance recertification application, submitted by DOE in March 2004 [6], EPA's review and a review by DOE itself identified a few errors in the codes, DOE had updated inventory data, and EPA required the use of increased solubility values to account for more recent experimental data than was used the CRA performance assessment. Thus, EPA required another set of performance assessment baseline calculations (PABC). The contribution of mean cuttings and cavings releases to total mean radionuclide releases for the PABC are similar to the PAVT. In the PABC, direct brine releases supplant spallings as the second-most important contributor to total releases and even surpass cuttings and cavings at low probabilities.

Because of the increased actinide solubilities and associated uncertainties used in the calculations, and higher brine saturations caused by lower gas generation rates, the contribution of DBR to total mean direct radionuclide releases for the PABC was greater than for the PAVT. Spallings releases calculated for the PABC were lower than those calculated for the PAVT. This reduction in calculated spallings releases was caused in part by revisions to the spallings model. In addition, lower long-term microbial gas generation rates resulted in lower PABC spallings releases because of the prediction of lower repository pressures than the PAVT.

2.6 Second Compliance Recertification Application

As with the certification and first recertification performance assessment, changes in inventory and other minor changes caused EPA to require a second performance assessment (PABC 2009) [7] for the second recertification [8]. In the most recent recertification the combination of parameter changes and model implementation combined to increase releases in the PABC 2009. Increases in radionuclide solubilities as a result of inventory changes in the PABC 2009 led to greater amounts of mobilized radionuclides calculated by the PANEL computer code and available for direct brine releases. For the PABC 2009, the upper range of the actinide solubility was increased from past performance assessments. In addition, the inventory of organic ligands was estimated to be much higher than in previous performance assessments because of new approaches to estimating the amount organic ligands in the inventory. Organic ligands, such as EDTA and citrate, increase actinide solubility. The computer code assumes that the dissolved organic ligand concentration is always the same, regardless of the brine volume in the repository; that is, there is no dilution with larger brine volumes. This was not identified as an issue when there was a small amount of organic ligands, but with the combination of changes, it has a noticeable effect on releases. Direct brine releases thus may be pessimistic (be larger than should be expected), because the volume of brine used in PANEL to calculate mobilized radionuclides per brine volume does not limit the volume of brine available for DBR in the code that does the final calculation of releases. [9] While acceptable, the implementation of the code needs to be examined to determine if it should be change to provide more realistic results.

3.0 Observations and Conclusions

WIPP has been in operation for twelve years and has had three sets of performance assessments conducted for it. WIPP has shown compliance with the standards each time. However, each performance assessment has had higher releases calculated than the previous performance assessment. There are several primary reasons for the increase: parameter changes due to new information, regulator review, and updated modeling assumptions. Most parameter changes involve the adoption of conservative approaches that overestimate releases, such as the change to the shear strength value during the original certification. EPA typically has identified parameters that have weak justifications, and DOE has adopted parameter changes that are conservative rather than developing defensible justifications for more realistic values. Especially during the initial certification, DOE frequently chose parameter values that were expedient and defensible, but contributed to higher releases than would be expected if experimental data had been collected and used. In other cases, DOE has acquired new information which has changed its understanding of the waste system. This was the case for changes to estimated organic ligand inventory. In reviewing data from the waste generator sites, DOE identified a potential underestimation of the organic ligand inventory and a new estimation approach. This new approach may be too high, and it may be re-evaluated for the next performance assessment for the inventory estimation as well as highlighting a code implementation issue.

In summary, a site developer may have the choice of spending fewer resources in obtaining data that is more conservative or spending more resources and getting more realistic information. As a regulator, given options that appear to be adequate, the tendency will be to accept the approach that would produce greater releases, because it is easier to justify. Thus, conservative assumptions are attractive to the site developer because they are easily adopted, and attractive to the regulator because they are easily defended. The use of many conservative assumptions, particularly for sensitive parameters, can significantly impact predicted long-term site performance, decreasing the margin by which the site developer is able to comply with numeric regulatory standards.

4.0 REFERENCES

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